
Antiproton Stacking and Cooling

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Temple Review
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Stochastic Stacking

- van Der Meer solution:

- Constant Flux:

$$\frac{\partial \psi}{\partial t} = \text{constant}$$

- Solution:

$$\frac{\partial \psi}{\partial E} = \frac{\psi}{E_d}, \text{ where } E_d \text{ characteristic of design } \psi = \psi_0 \exp\left[\frac{(E - E_i)}{E_d}\right]$$

- Exponential Density Distribution generated by Exponential Gain Distribution

- Max Flux = $(W^2 |\eta| E_d) / (f_0 p \ln(F_{max}/F_{min}))$

- W bandwidth, F_{max} and F_{min} frequency range
 - f_0 beam revolution frequency, p beam momentum
 - $|\eta|$ phase slip factor
 - E_d characteristic gain slope

Stacktail Design Scenario

- Goal: 80 mA/hour peak stacking rate in Accumulator
 - x2 design margin above 40 mA/hour
- Accumulate for 30-60 minutes, transfer to Recycler
 - Optimize for maximum flux, not momentum density
 - Maximum stack size 50-60 mA to avoid significant falloff in stack rate
 - Consistent with current systems
- Change Bandwidth & E_d
 - 2-6 GHz
 - 9 MeV gain slope
 - Maximum flux ~ 102 mA/hour

Specifications

■ Input:

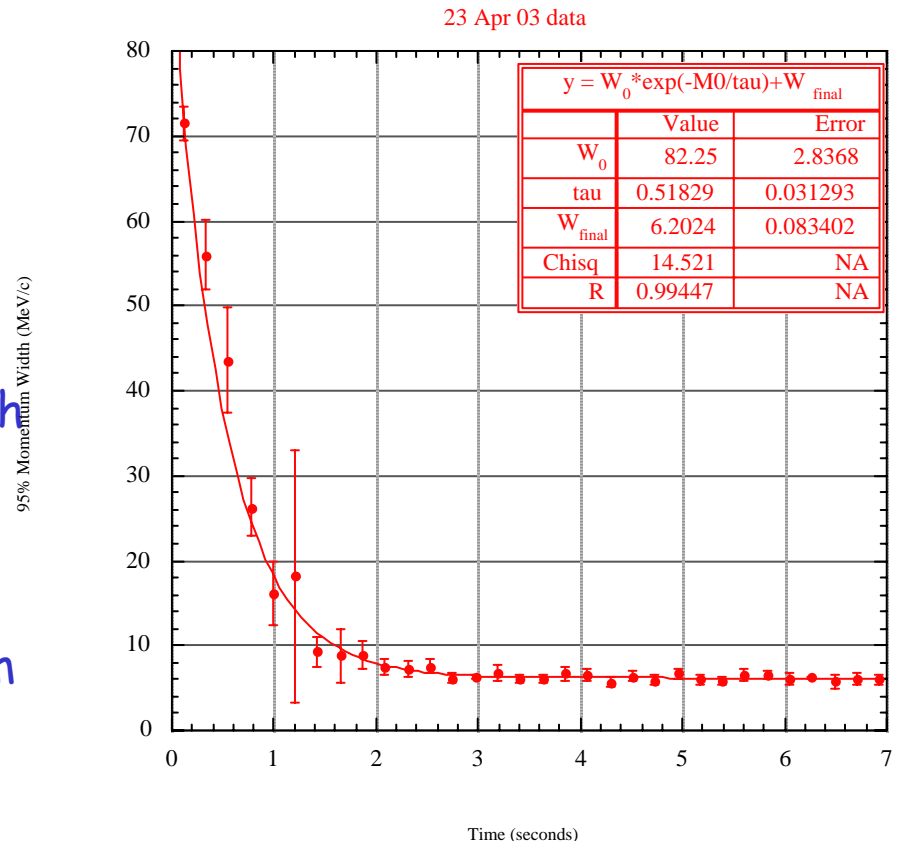
- 50 π transverse emittance
- 6 MeV/c 95% momentum width
- 2 second cycle time

■ Output:

- 30-60 minutes accumulation time
- ~1 minutes extraction
- Extract
 - 10 eV-sec
 - Transverse $\sim 12 \pi$

Current Debuncher Performance

- Large initial momentum
- Exponential decay time:
 - 0.5 sec
- @ 2 seconds:
 - 7.9 \pm 0.4 MeV/c
- Improvement to notch filter equalizers to:
 - Minimize asymptotic width
- Improvement to MI bunch rotation
 - Minimize initial momentum spread



Design Decision

- 2-6 GHz total bandwidth in parallel systems

- 2-4 GHz band

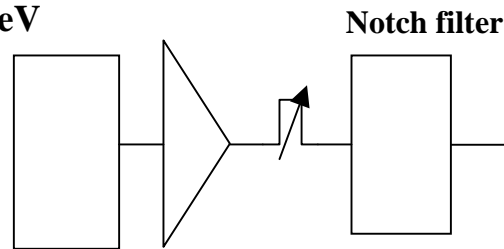
- Equivalent to current stacktail
 - Utilize existing hardware
 - Replace $1/2$ system

- 4-6 GHz band

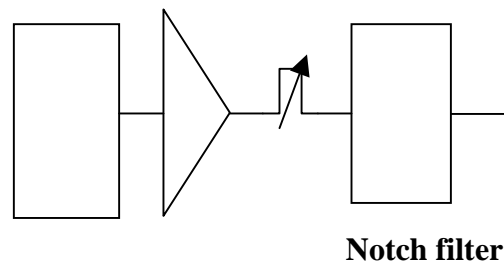
- New hardware
 - Pickup & Kicker loops
 - » New design?
 - Electronics

- Layout similar for both systems

128/256 Pickup
Loops @ -5
MeV



A60



32/64 Pickup
Loops @ -22
MeV

Two Independent Systems

2-4 GHz

4-6 GHz

With similar layouts

128/256 Kicker
loops

Notch filter

Σ

16/16 TWTs

A30

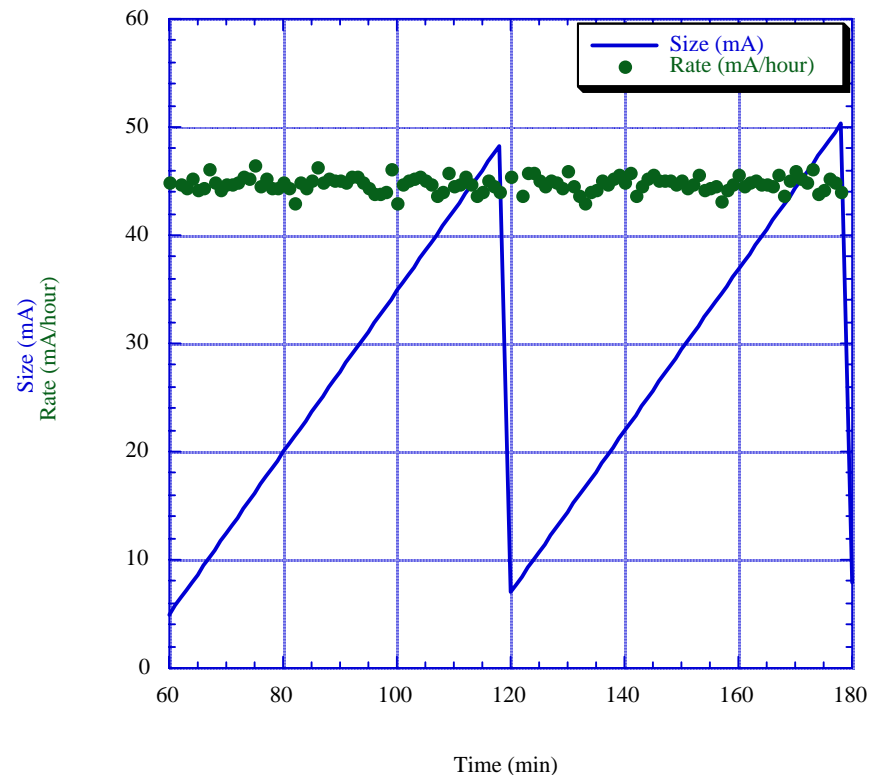
Core position -52 MeV
4-8 GHz system

System Parameters

	2-4 GHz System (1/2 current system)	4-6 GHz System To be built
Pickup loops	160	320
Kicker Loops	128	256
Loop Impedance	20 Ω	5 Ω (current) 10 Ω (desired)
Front End Noise Temperature	125 K	125 K
Cryo Amps	8	8
1 Watt Amps	8	8
BAW Notch Filters	3	3
TWTs	20	20
TWT Power Supplies	20	20
Total Power	~500 W	~500 W

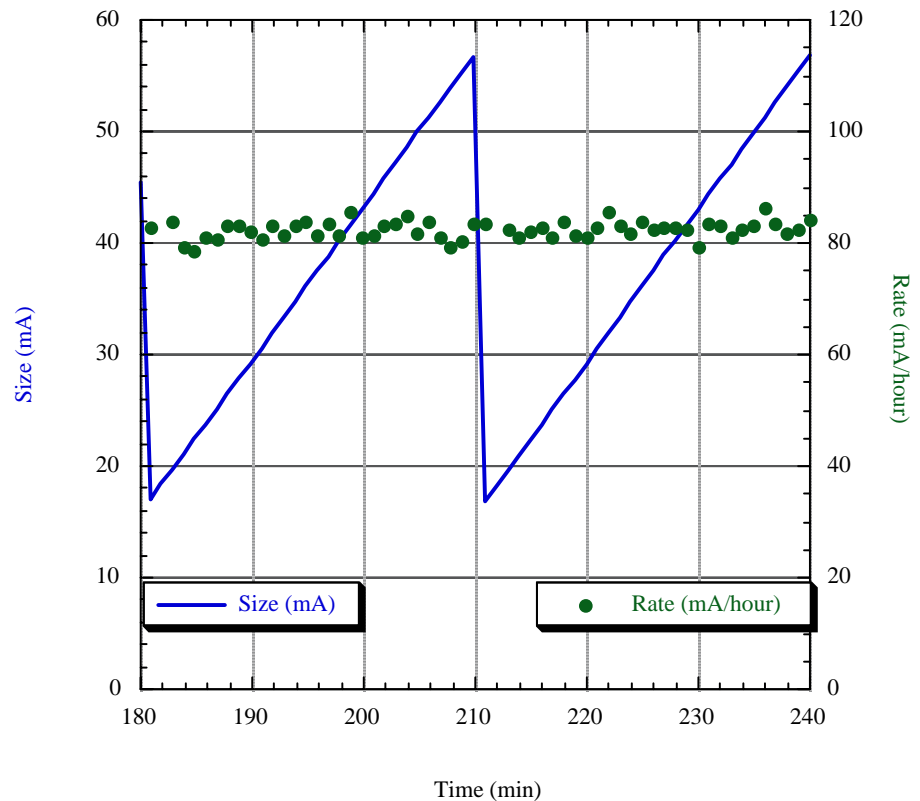
Results

- Time integration of Fokker-Planck equation, including feedback effects
- Sustains 45 mA/hour for 60 minutes
- Transfer ~ 45 mA every 60 minutes



Results

- Time integration of Fokker-Planck equation, including feedback effects
- Sustains 80 mA/hour for 30 minutes
- Transfer ~ 40 mA every 30 minutes



Schedule

- Debuncher Cooling: WBS 1.3.3.2
 - Characterize and understand current system performance
 - Start Date: 1 March 03
 - Duration: 66 days
- Stacktail Cooling: WBS 1.3.3.3
 - Momentum: WBS 1.3.3.3.1
 - Change the characteristic gain slope and increase the bandwidth of the stacktail momentum cooling system to handle input flux of greater than 40 mA/hour
 - Start Date: 1 March 03
 - Duration: 709 days
 - Cost Driver: TWTs and power supplies
 - Schedule Drivers: TWT Procurement, Installation (matching to shutdowns)
 - Betatron: WBS 1.3.3.3.2
 - Install a new stacktail betatron system to give additional transverse cooling during the stacking process. At this time, it is not clear whether such a system is required. The branch point to continue with this project is the system design milestone.
 - Start Date: 3 March 03
 - Duration: 709 Days
 - Schedule Drivers: TWT Procurement, Installation (matching to shutdowns)

Costing

Stage 2 Stacktail Cooling Upgrade to 4-6 GHz

Hardware	Quantity	Unit cost	Line total
Cryogenic preamplifiers	8	\$4,000	\$32,000
Secondary preamps	8	\$1,000	\$8,000
BAW notch filters	3	\$10,000	\$30,000
TWT	20	\$20,000	\$400,000
TWT power supply	20	\$18,000	\$360,000
Coax cables	1	\$10,000	\$10,000
Support microwave hardware	1	\$100,000	\$100,000
Pickup array boards	8	\$500	\$4,000
Kicker array boards	16	\$500	\$8,000
Set up charge for array boards	1	\$10,000	\$10,000
Machine shop	1000	\$40	\$40,000
Electricians for cables pulls man weeks	2	\$1,000	\$2,000
subtotal			\$1,004,000
Contingency @ 30%			\$301,200
TOTAL			\$1,305,200
Labor Estimate			
Array engineering		man months	6
Array fabrication		man months	6
System engineering		man months	2
Installation technicians		man months	6
Mechanical engineering		man months	3